North Complex Climate Analysis

Summary

- By mid-century (2040-2069), only 28% of the area burned by the North Complex Fire will support suitable conditions for vegetation types present prior to the fire, and this number will decrease to 7% by the end of the century (2070-2099).
- Vegetation types that are most likely to persist in their pre-fire footprint by the end of the century include montane hardwood conifer, montane hardwood, and Sierra mixed conifer, while those that are unlikely to persist in their pre-fire footprint by the end of the century include red fir, Douglas fir, and blue oak woodlands.
- Management areas that are likely to experience the greatest increase in climatic water deficit (an indication of drought stress for all vegetation types) by the end of the century include French Creek, Galen, and Kellogg. Areas that will experience smaller increases in climatic water deficit by end-century include North Fork, Lost Creek, and Challenge.
- Galen and Grizzly Ridge management areas have low probability of natural regeneration and are not predicted to support any of the vegetation present prior to the North Complex Fire by the end of the century, meaning that efforts to plant conifers in these areas will likely be unsuccessful in the long-term.
- We found a number of areas (12,000 acres) that unlikely to regenerate naturally but will still support suitable conditions for conifer vegetation types at the end of the century, primarily in the Lost Creek and Pinchard management areas. These locations should be considered the highest priority for post-fire planting efforts.

Climate Refugia

We used spatial data compiled by Thorne et al. (2020) to identify vegetation refugia. These are areas where vegetation occurring prior to the North Complex Fire is expected to persist under future projected climates. For this analysis we focused on projections from the Model for Interdisciplinary Research on Climate–Earth System which represents a hotter and drier future (Watanabe et al. 2011) in combination with the "business as usual" emissions scenario of representative concentration pathway 8.5 (MIROC 8.5).

Mid-century (2040 – 2069)

Areas that are likely to maintain suitable conditions for vegetation present prior to the North Complex Fire by the middle of the century (2040 – 2069) are shown in Figure 1. Areas that supported annual grasslands prior to the fire, and vegetation types with less than 50 acres of mid-century refugia, such as red fir and blue oak woodlands, were excluded from this analysis.
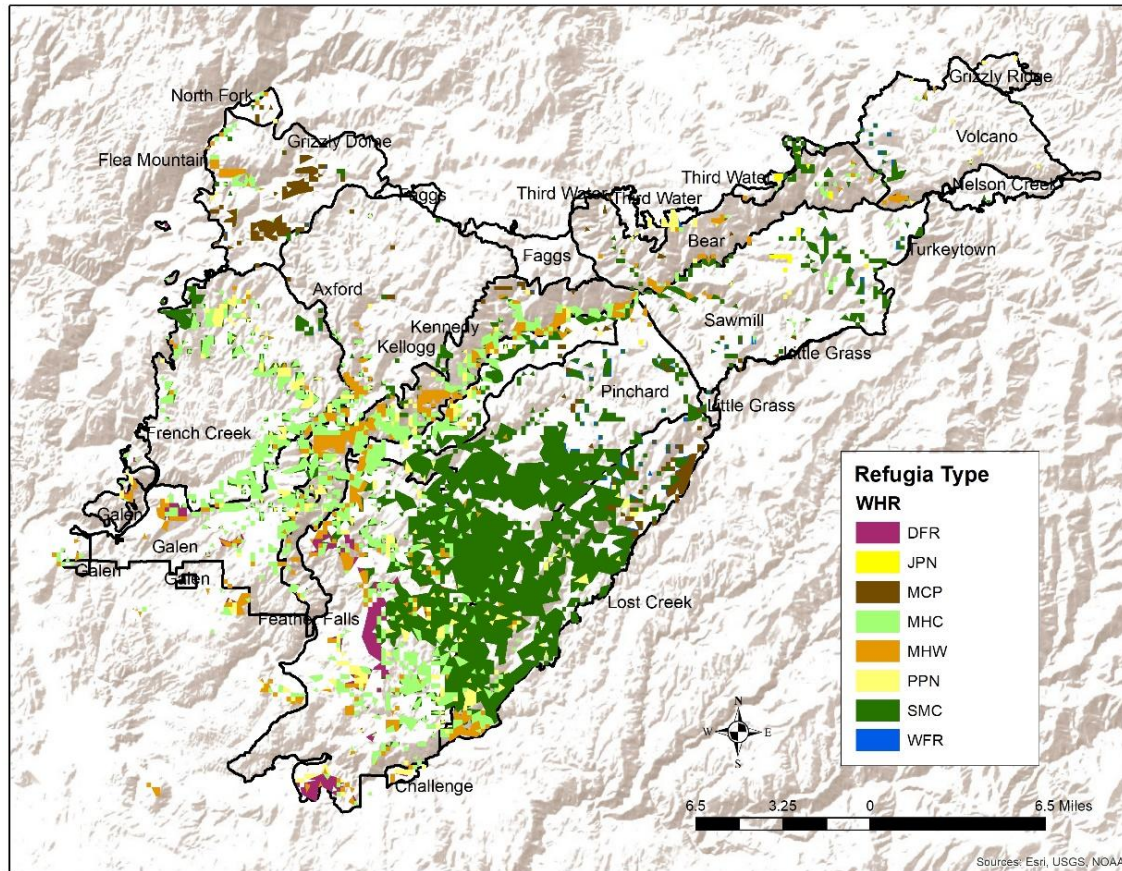

Figure 1. Areas identified as refugia by the middle of the century (2040 and 2069) for vegetation present prior to the North Complex Fire (T:\FS\NFS\Plumas\Project\SO\NorthComplexFire_LandscapeAssessment\GIS\Workspace\kmerriam\Refugia). CWHR codes are provided in Appendix 1.

Mid-century refugia comprise 74,341 acres, or 28% of the total area burned by the North Complex Fire (Table 1). Refugia are concentrated in the southeastern portions of the fire area, including the Feather Falls, Lost Creek and Pinchard management areas. Vegetation types that are likely to persist in these areas are primarily Sierra mixed conifer (54% of refugia) and montane hardwood conifer (21% of refugia). Other vegetation types with more than 50 acres of mid-century refugia in the North Complex Fire area include Douglas Fir, Jeffery Pine, montane chaparral, montane hardwood, ponderosa pine, and white fir.

Table 1. Acres of mid-century refugia by vegetation type identified in each management area of the North Complex Fire area. Final row shows refugia for each CWHR type as a percentage of all refugia. CWHR codes are provided in Appendix 1.

Management Area	DFR	JPN	MCP	MHC	MHW	PPN	SMC	WFR	Total Refugia Acres
Axford	0	0	92	283	364	72	398	7	1220
Bear	0	43	82	193	377	120	475	11	1301
Challenge	8	0	0	23	49	95	0	0	174
Feather Falls	1692	0	66	4715	1802	1429	7618	3	17324
French Creek	0	0	10	3082	265	1001	1231	5	5594
Galen	202	0	0	1658	584	284	170	0	2899
Grizzly Dome	8	0	1508	334	322	38	202	26	2440
Kellogg	15	0	164	3465	2345	574	458	9	7030
Kennedy	0	0	86	852	396	234	1409	16	2993
Little Grass	0	0	2	0	0	0	38	4	44
Lost Creek	0	5	1026	634	481	716	12297	167	15326
North Fork	0	0	65	9	35	6	12	0	127
Pinchard	0	18	155	100	146	36	13319	193	13966
Sawmill	0	173	93	172	114	45	1995	117	2720
Third Water	0	62	11	12	18	191	177	9	491
Volcano	0	0	4	28	153	66	302	69	641
% of all Refugia	3	1	5	21	10	7	54	1	28

End-century (2070-2099)

Areas that are likely to maintain climatic conditions suitable for vegetation present prior to the North Complex Fire by the end of the century (2070– 2099) are shown in Figure 2.
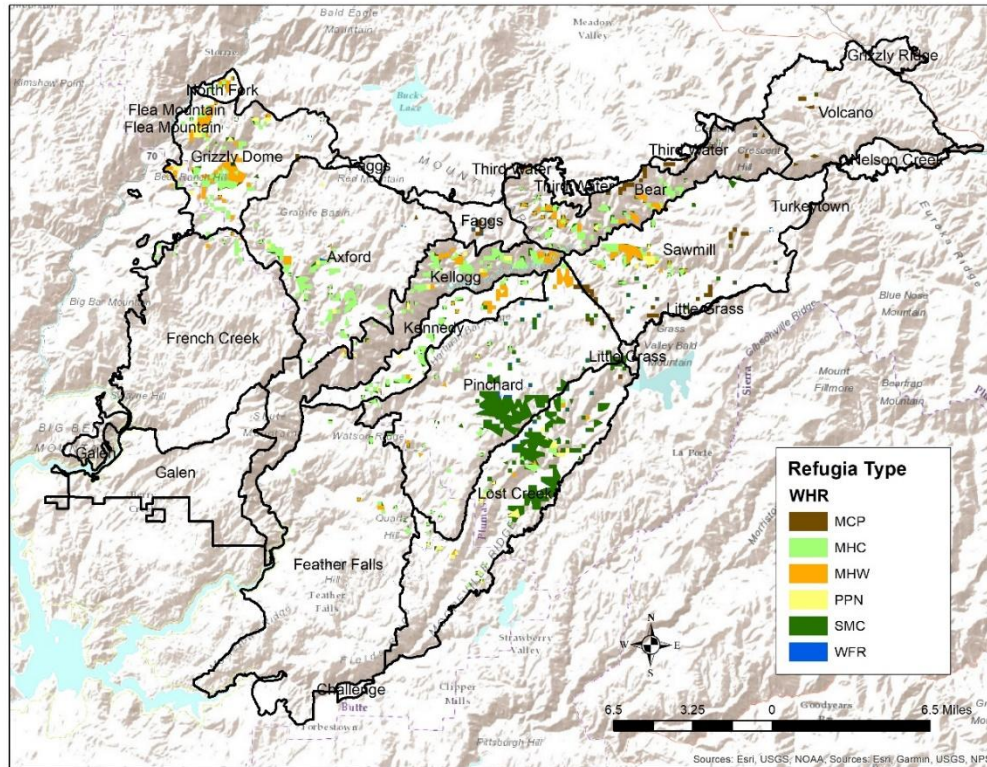

Figure 2. Areas identified as refugia by the end of the century (2070-2099) for vegetation present prior to the North Complex Fire (T:\FS\NFS\Plumas\Project\SO\NorthComplexFire_LandscapeAssessment\GIS\Workspace\kmerriam\Refugia). CWHR codes are provided in Appendix 1.

End-century refugia comprise only 18,338 acres, or less than 7%, of the total area burned by the North Complex Fire (Table 2). Refugia are concentrated in the higher elevation portions of the fire. Management areas with the greatest total acres of end-century refugia include Lost Creek, Pinchard, and Grizzly Dome. Vegetation types that are likely to persist in these areas are primarily Sierra mixed conifer (33%), montane hardwood conifer (33%), and montane hardwood (18%).

Table 2. Acres of end-century refugia by vegetation type identified in each management unit of the North Complex Fire area. Final row shows refugia for each CWHR type as a percentage of all refugia. CWHR codes are provided in Appendix 1.

Management Area	MCP	MHC	MHW	PPN	SMC	WFR	Total Refugia Acres
Axford	25	1194	83	66	83	20	1471
Bear	265	783	565	38	201	9	1861
Faggs	105	0	0	0	0	36	141
Feather Falls	1	135	41	0	38	0	215
French Creek	0	159	46	0	21	0	226
Grizzly Dome	66	1024	981	293	110	4	2478
Kellogg	15	1037	435	152	88	0	1727
Kennedy	0	579	278	70	164	2	1093
Little Grass	1	0	0	0	31	1	33
Lost Creek	51	235	77	375	2626	80	3444
North Fork	11	72	108	0	7	0	197
Pinchard	129	360	297	27	2419	121	3354
Sawmill	478	438	442	119	287	51	1815
Third Water	72	1	9	30	0	0	112
Volcano	103	0	14	0	30	0	147
% of Refugia	8	33	18	6	33	2	7

Projected changes in vegetation type

To evaluate projected changes in vegetation within the North Complex Fire area, we compared acres present prior to the fire, acres of refugia expected to remain by mid-century, and acres of refugia present at the end of the century, for each vegetation type present prior to the North Fire Complex Fire, excluding annual grasslands and vegetation types occupying less than 400 acres prior to the fire. We also computed the percent change from pre-fire acres for both mid-century and end-century time steps (Table 3). We found that on average vegetation types will be reduced to about 4% of their current footprint by end-century. However, some vegetation types will maintain greater than average amounts of refugia, including montane hardwood conifer, montane hardwood, and montane chaparral. Vegetation types that are unlikely to persist in their pre-fire footprint by the end of the century include red fir, Douglas fir, and blue oak woodlands. This does not mean that these vegetation types might occur elsewhere in the fire footprint, such as at higher elevations or in different topographical positions than their current distribution, in the future.

Table 3. Vegetation types within the North Fire Complex, including pre-fire acres, mid-century refugia acres, end-century refugia acres, and % change for each time step. Vegetation types with greater than average amounts of refugia by end-century are shown in the top portion of the table, while those with lower than average refugia are shown in the bottom portion of the table. CWHR codes are provided in Appendix 1.

	WHR	Pre-fire Acres	Mid-century Refugia Acres	% change mid-century	End-century refugia acres	% change end century
Better than average	MHC	34104	15559	-54	6016	-82
	MHW	20960	7451	-64	3378	-84
	MCP	9466	3364	-64	1348	-86
	PPN	10350	4938	-52	1170	-89
	JPN	1023	302	-71	60	-94
	SMC	132821	40120	-70	6103	-95
	Average	*277240*	*31336*	*-89*	*12280*	*-96*
Worse than average	MCH	911	19	-98	25	-97
	WFR	46906	635	-99	323	-99
	RFR	2337	48	-98	2	-100
	BOP	450	11	-98	0	-100
	DFR	12598	1925	-85	0	-100

Climatic water deficit

Climatic water deficit (CWD) is the evaporative demand that is not met by available water and provides an index of the amount of drought stress experienced by plants (Stephenson 1988). We analyzed both current and projected future CWD (CBI 2020) to provide an overview of climatic conditions for all vegetation types in the North Fire Complex area, instead of focusing on climate refugia for specific vegetation types (described above).

Current (1981-2010)

Climatic water deficit in the North Complex Fire area ranges from 139 to 877 mm, with the highest CWD (indicating the driest and most stressful conditions for plants) occurring in the western and southern portions of the fire area, and the lowest deficits found in the eastern and northern portions of the fire (Figure 3). Management areas with the lowest current mean CWD include Lost Creek, Pinchard, and Faggs, while the highest CWD is found in low elevation management areas including Galen, French Creek, Kellogg and Feather Falls.
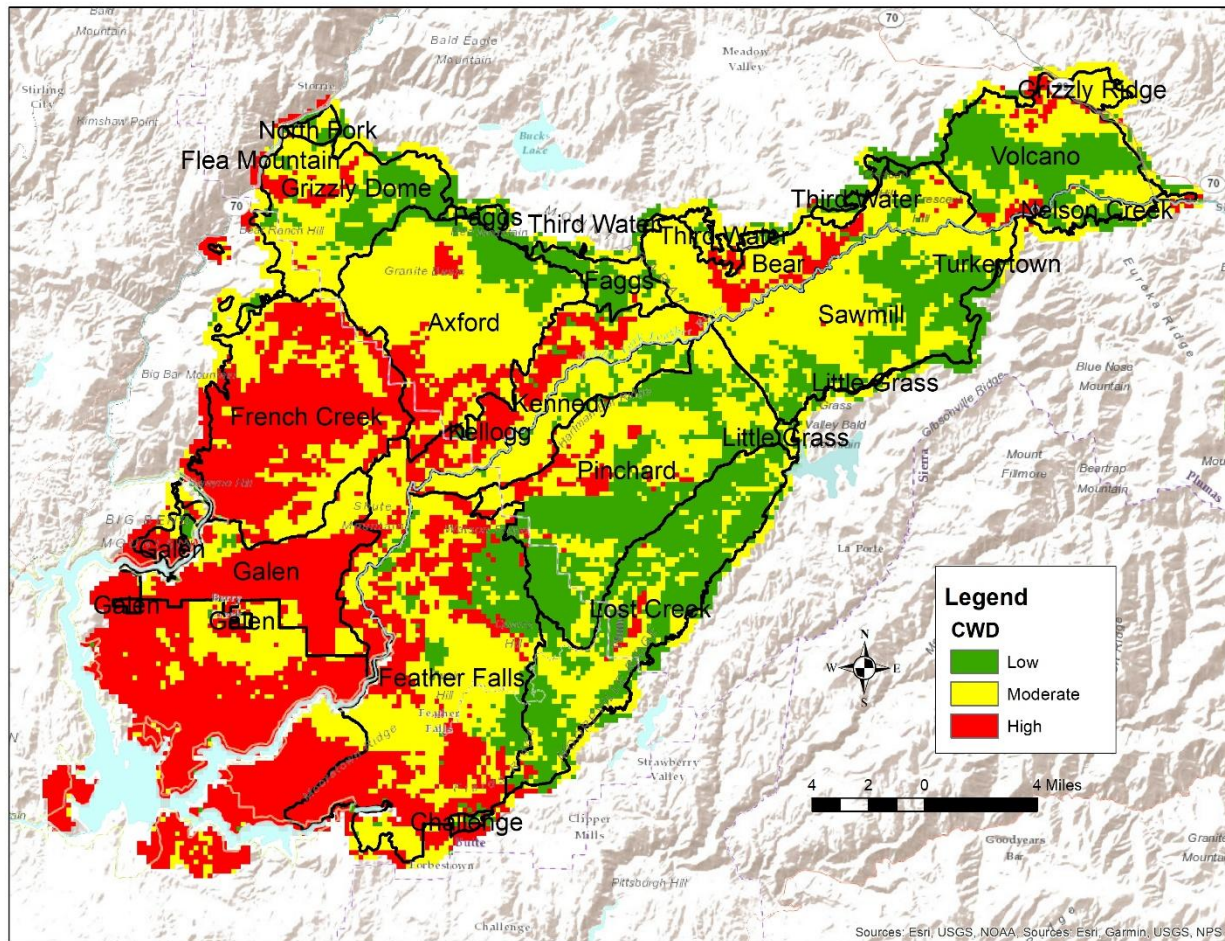

Figure 3. Current (1984-2010) climatic water deficit in the North Complex Fire area. Data from CBI (2020). (T:\FS\NFS\Plumas\Project\SO\NorthComplexFire_LandscapeAssessment\GIS\Workspace\kmerriam\ClimaticWaterDeficit)

Projected Future (2070-2099)

Projected changes in CWD by the end of the century are shown in Figure 4. These projections were made using the same MIROC 8.5 climate model that was used for the refugia analysis above (CBI 2020). Management areas that are likely to experience the greatest increase in CWD include French Creek, Galen, and Kellogg, while areas that are likely to experience least increase in CWD by the end of the century include North Fork, Lost Creek, and Challenge. However, these areas may still be highly drought-stressed by 2070-2099.
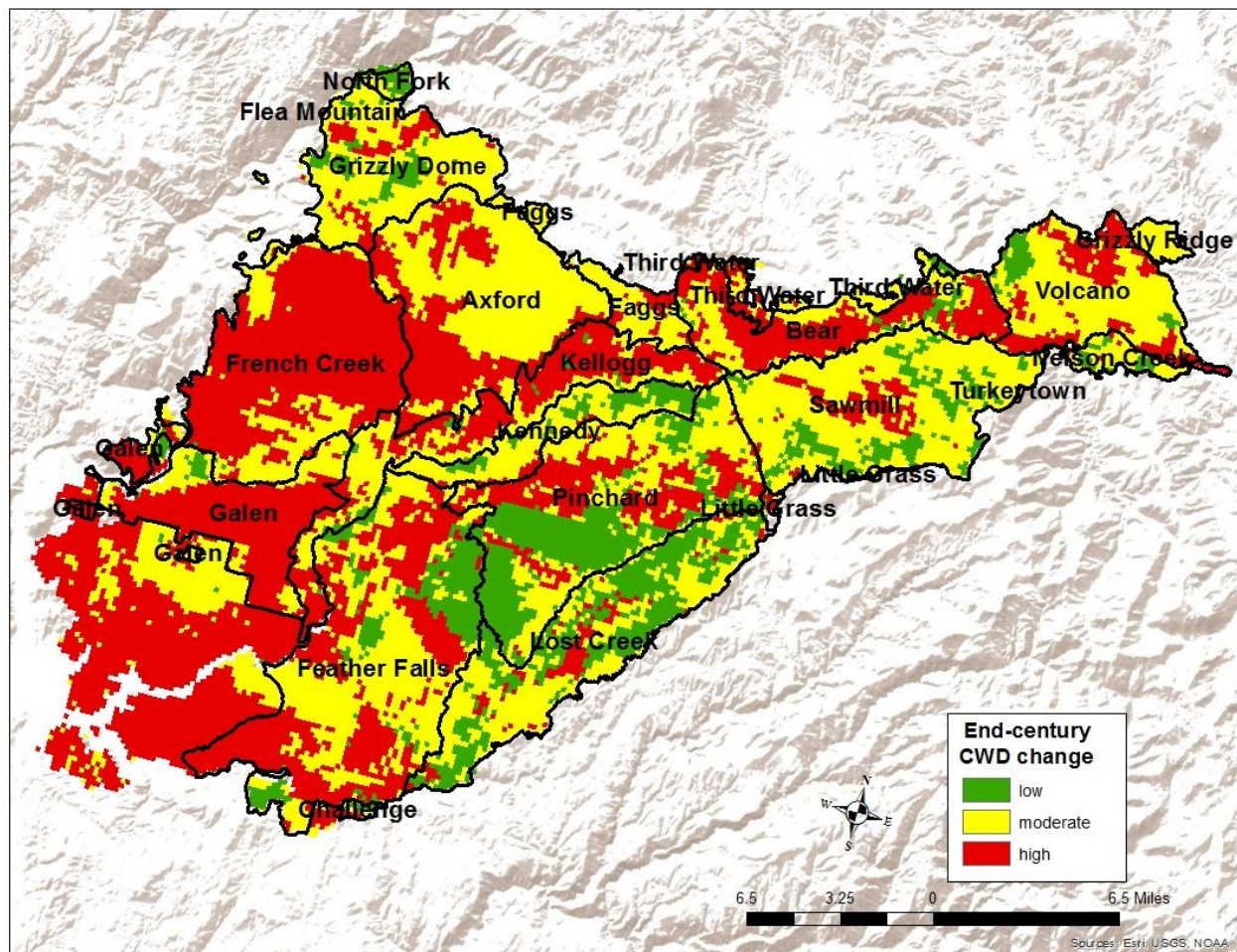

Figure 4. Projected changes in CWD by the end of the century under the MIROC 8.5 climate model. Data from CBI (2020). (T:\FS\NFS\Plumas\Project\SO\NorthComplexFire_LandscapeAssessment\GIS\Workspace\kmerriam\ClimaticWaterDeficit)

8

Management Areas

To develop specific recommendations for each management area, we combined data on climate refugia and climatic water deficit (described above), with additional data on fire severity and regeneration probability, to generate an overview of current and projected conditions within the management areas affected by the North Complex Fire (Table 4).

Table 4. Mean current and projected future conditions by management area, including regeneration probability, current CWD, percent of the management area that burned at high severity, and end-century increases in CWD. Management areas are shown in order of mean regeneration probability.

Management Area	Mean Regeneration Probability (%)	Mean CWD (current)	% High Severity	End-century Refugia Acres	End-century CWD Increase
Pinchard	53	539	21	3372	845
Galen	53	678	40	0	941
Feather Falls	54	617	1	215	889
French Creek	60	668	17	226	942
Kellogg	64	632	70	1742	913
Grizzly Ridge	65	581	68	0	875
Lost Creek	67	505	71	3452	806
Volcano	68	563	31	147	867
Sawmill	74	547	25	1881	847
Nelson Creek	78	558	29	27	854
Axford	78	592	59	1710	905
Bear	79	603	25	1883	911
Kennedy	80	579	21	1093	831
Challenge	80	583	60	0	825
Grizzly Dome	81	572	93	2567	852
Little Grass	81	546	7	33	848
Faggs	83	539	44	192	878
North Fork	84	557	37	197	800
Third Water	84	577	4	112	839

Management areas with less than 70% probability of natural regeneration on average include Pinchard, Galen, Feather Falls, French Creek, Kellogg, Grizzly Ridge, Lost Creek and Volcano. Of these, Galen and Grizzly Ridge are not predicted to support any of the vegetation present prior to the fire by end-century, meaning that efforts to plant conifers in these areas will likely be unsuccessful in the long term. These management areas also have some of the highest projected increases in CWD by end-century. On the other hand, Pinchard and Lost Creek management areas both support over 3000 acres of refugia for existing vegetation types by end-century, and face relatively lower increases in CWD. In combination, these data suggest that Pinchard and Lost Creek might be prioritized for post-fire restoration of existing vegetation types, which is primarily Sierra mixed conifer (see Table 2).

Regeneration Probability

Finally, we evaluated areas where probability of post-fire regeneration occurring naturally was less than 40%, but that were also projected to be end-century refugia for conifer vegetation types (Table 5). Approximately 12,000 acres meet these criteria, primarily in the Lost Creek and Pinchard Management Areas.

Table 5. Acres of end-century refugia by WHR type where post-fire regeneration probability is less than 40%. CWHR codes are provided in Appendix 1.

Management Area	MHC	PPN	SMC	WFR	Total Acres
Axford	1171	66	82	18	1338
Bear	574	27	139	2	743
Faggs	0	0	0	21	21
Feather Falls	122	0	35	0	157
French Creek	159	0	20	0	178
Grizzly Dome	744	269	95	3	1112
Kellogg	954	137	79	0	1169
Kennedy	565	66	149	2	781
Little Grass	0	0	22	1	23
Lost Creek	219	351	2359	65	2994
North Fork	63	0	2	0	65
Pinchard	347	27	2177	112	2663
Sawmill	389	101	250	43	783
Third Water	0	29	0	0	29
Volcano	0	0	29	0	29

Specific locations meeting these criteria are show in Figure 5. These locations should be considered the highest priority for post-fire planting efforts as they are unlikely to regenerate naturally but will support suitable conditions for conifer vegetation types occurring prior to the fire by the end of the century.
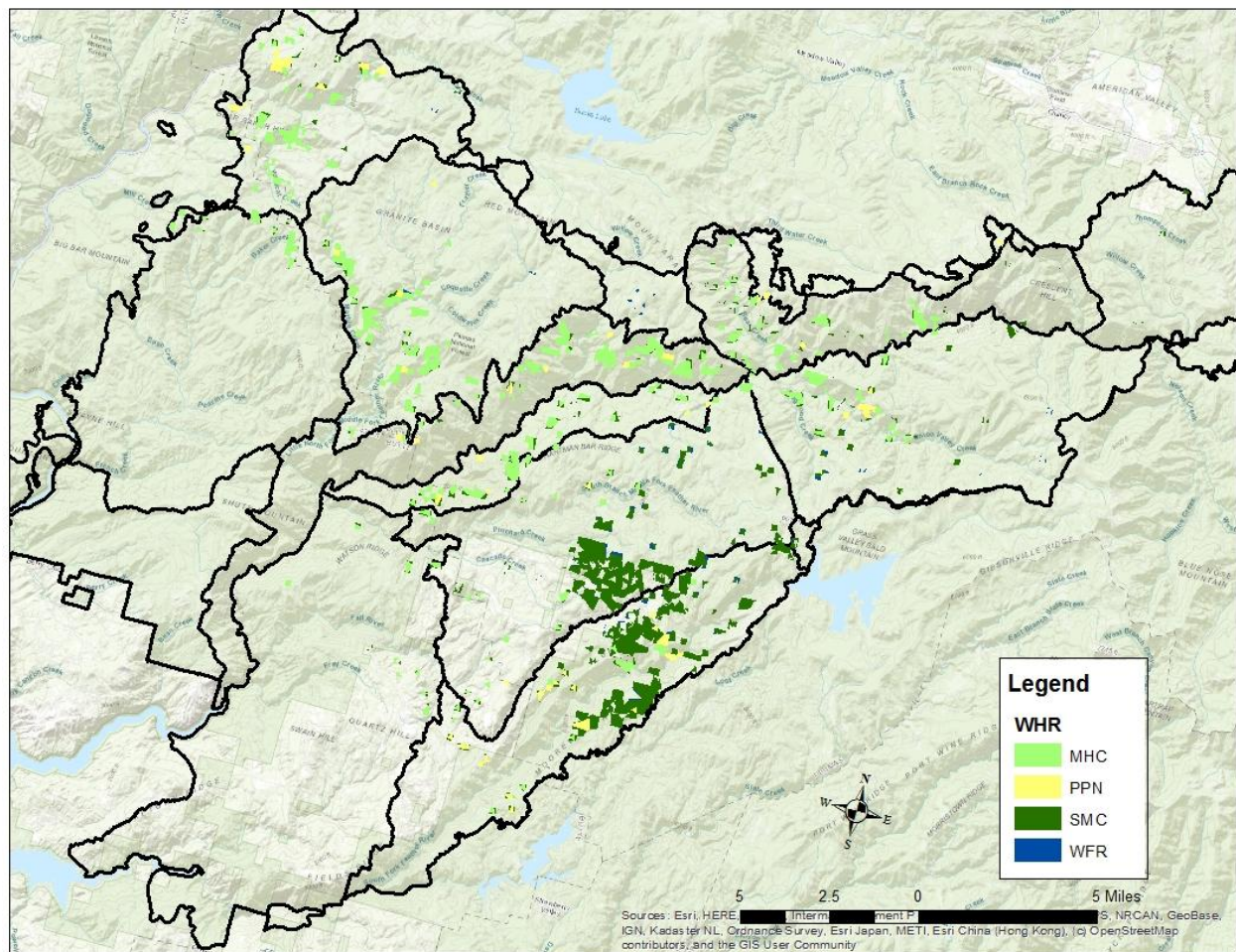

Figure 5. Areas where probability of post-fire regeneration occurring naturally is less than 40%, and that are also projected to be end-century refugia for conifer vegetation types. CWHR codes are provided in Appendix 1.
(T:\FS\NFS\Plumas\Project\SO\NorthComplexFire_LandscapeAssessment\GIS\Workspace\kmerriam\Figure6.mxd)

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Appendix 1. CWHR Vegetation Type Codes

CWHR code	Type Description
BOP	Blue Oak Woodland
DFR	Douglas Fir
JPN	Jeffrey Pine
MCH	Mixed Chaparral
MCP	Montane Chaparral
MHC	Montane Hardwood-Conifer
MHW	Montane Hardwood
PPN	Ponderosa Pine
RFR	Red Fir
SMC	Sierra Mixed Conifer
WFR	White Fir